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(72) Inventor: Russell, Richard Charles  
Red Hook, NY 12571 (US)

(74) Representative:  
Burrington, Alan Graham Headford  
Alan Burrington & Associates  
4 Burney Close  
Great Bookham  
Leatherhead, Surrey KT22 9HW (GB)

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(71) Applicant: INTERNATIONAL BUSINESS  
MACHINES CORPORATION  
Armonk, NY 10504 (US)

(54) System of propagating a command status code from a remote unit to a host unit

(57) Propagation of a command status code from a remote unit to a host unit. A command to be executed on a remote unit is passed from a host unit to the remote unit, using a remote command execution facility, such as the remote shell (RSH) facility of UNIX. The command is executed on the remote unit and the status code of the command is forwarded from the remote unit to the host unit, using the remote command execution facility. In one example, the status code is appended to standard output, so that it can be retrieved and used in further processing.

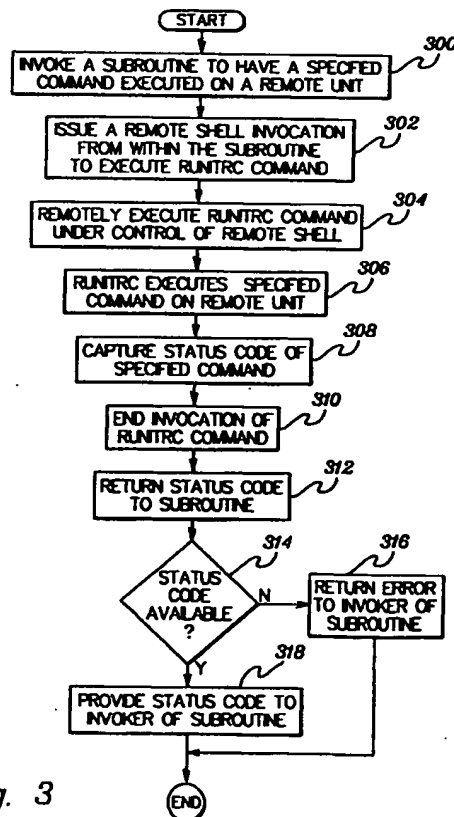


fig. 3

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## Description

[0001] This invention relates, in general, to the remote execution of commands and, in particular, to the receipt at a host unit of the status of a command executed on a remote unit.

[0002] This application contains subject matter which is related to the subject matter of the following United States applications, which are assigned to the same assignee as this application and filed on the same day as this application. The below listed applications are hereby incorporated herein by reference in their entirety:

"Method Of Propagating A Command Status Code From A Remote Unit To A Host Unit," by Richard C. Russell, Serial No. 08/892,782, (Docket No. PO9-97-012); and

"Propagation Of A Command Status Code From A Remote Unit To A Host Unit," by Richard C. Russell, Serial No. \_\_\_\_\_, (Docket No. PO9-97-083).

[0003] Within many computer environments, multiple processors are connected to one another using typical telecommunications connections, such as TCP/IP or token rings.

[0004] In these environments, there is often a need or desire to execute a command on one processor, when logged onto another processor. That is, there is a need or desire to execute the command remotely.

[0005] In, for instance, UNIX-based operating systems, a command can be executed remotely using a remote shell (RSH) facility. Often, the remote shell facility is invoked from within a shell script that includes one or more statements. When the shell script is run, each statement is executed one at a time.

[0006] When the shell script invokes the RSH facility, the RSH facility causes a specified command to be executed at a specified network-connected remote processor. That is, the specified command is run on the remote processor via RSH and the results of the specified command are returned back to the host processor (i.e., the processor issuing the request). The results include "standard output", which is the output of the specified command, and "standard error", which includes any error messages that were generated by the command. However, neither "standard output" nor "standard error" includes the status code (e.g., the return code or the exit code) of the executed specified command.

[0007] In particular, when the specified command is executed remotely, it generates a status code. However, RSH is incapable of returning the status code to the host processor. Instead, the status code of the specified command is lost and/or disregarded, and what is returned is the status condition of the RSH facility.

[0008] Since the status code of the specified command is not returned to the host processor, further

processing to take place after execution of the specified command (e.g., processing within the script) is tenuous, at best. This is due to the uncertainty of whether the specified command executed successfully or not.

[0009] Based on the foregoing, a need exists for a capability that enables the return of the status code of a remotely executed command, when the command is executed using a facility, such as RSH.

[0010] The shortcomings of the prior art are overcome and additional advantages are provided through the provision of a system of propagating a status code from a remote unit to a host unit. A host unit is adapted to pass from the host unit to a remote unit a command to be executed on the remote unit.

[0011] The host unit uses a remote command execution facility. The remote unit is adapted to execute the command, and to forward a status code of the command from the remote unit to the host unit. The remote unit also uses the remote command execution facility to forward the status code.

[0012] In one embodiment, the host unit is further adapted to issue a remote command execution facility invocation to execute the command on the remote unit. The remote command execution facility invocation identifies the command.

[0013] In a further embodiment, the remote command execution facility invocation is issued from within a subroutine, and the subroutine is called from within a shell script or a computer program.

[0014] In yet a further embodiment, the remote unit is further adapted to run another command on the remote unit. The another command is identified on the remote command execution facility invocation, and the execution of the first command is under control of the another command.

[0015] In another embodiment of the present invention, the remote unit is further adapted to include the status code in standard output generated during execution of the command, and pass the standard output to the host unit.

[0016] In another embodiment of the present invention, a system of propagating a status code from a remote unit to a host unit is provided, which includes: means for invoking from within a subroutine on a host unit a remote command execution facility to execute a first command; means for executing the first command on a remote unit; means for executing a second command on the remote unit via the first command; and means for forwarding a status code of the second command from the first command on the remote unit to the host unit.

[0017] The capabilities of the present invention advantageously allow the return of a status code of a remotely executed command, via a remote command execution facility, such as RSH. The capabilities of the present invention are easily adaptable to the scripting environments and do not require the changing of operating system code. The capabilities of the present in-

vention enable the return of the status code, even if no other output is generated or is being returned to the host unit.

**[0018]** Additional features and advantages are realised through the techniques of the present invention. Other embodiments and aspects of the invention are described in detail herein and are considered a part of the claimed invention.

**[0019]** The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other objects, features, and advantages of the invention will be apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 depicts one example of a computer environment incorporating and using the status code propagation capability of the present invention;

FIG. 2 depicts one embodiment of further details within the computer environment of FIG. 1 incorporating and using the status code propagation capability of the present invention; and

FIG. 3 depicts one example of the logic associated with the status code propagation capability of the present invention.

**[0020]** In accordance with the principles of the present invention, a capability is provided in which a status code of a remotely executed command is returned to the host unit (e.g., the unit requesting execution of the command) via a remote command execution facility. In particular, the remote command execution facility, which was previously unable to return the status code, is adapted to allow the propagation of the status code from a remote unit to the host unit.

**[0021]** One example of a computer environment incorporating and using the status code propagation capability of the present invention is described in detail below with reference to FIG. 1.

**[0022]** Referring to FIG. 1, in one embodiment, a computer environment 100 includes a plurality of units 102 coupled to one another via a connection 104. In one example, each unit is a UNIX workstation running a UNIX-based operating system, and the units are coupled to one another via a TCP/IP connection.

**[0023]** Each unit includes, for instance, a central processing unit, memory and one or more input/output devices, which are well known in the art.

**[0024]** The above-described environment in which each unit is a UNIX workstation running a UNIX-based operating system is only one example, however. The status code propagation capability of the present invention can be incorporated and used with any type of computers, processors, systems, workstations and/or environments, without departing from the spirit of the

present invention.

**[0025]** For instance, in another embodiment, one or more of the units is a PS/2 offered by International Business Machines Corporation. In a further embodiment, one or more of the units is based upon the Enterprise Systems Architecture offered by International Business Machines Corporation. Further, the operating system need not be UNIX-based. For example, the operating system can include the Multiple Virtual Storage (MVS) operating system offered by International Business Machines Corporation. Additionally, connection 104 need not be TCP/IP. It can be any type of wire connection, token ring or network connection, to name just a few more examples.

**[0026]** In yet a further embodiment, the environment includes a large parallel system with a plurality of units (e.g., 512 nodes) coupled to one another via a network connection, such as a switch. Additionally, in other environments, the units can be of differing types connected to one another via one or more connections. The invention is not limited to a particular number of units coupled together nor the type of units that are coupled.

**[0027]** Again, other types of computers, processors, systems, workstations, and/or environments can include the status code propagation capability of the present invention, and all of these types are considered within the scope of the present invention.

**[0028]** In accordance with the principles of the present invention, at least one of units 102 is a host unit 102a, which is coupled to one or more remote units 102b. Commands invoked on a host unit (e.g., a local unit originating a request) are executed on one or more of the remote units. For instance, if a particular management function is to be carried out on a number of remote units, a specified command representing the management function is invoked at the host unit and remotely executed on the remote units.

**[0029]** In one embodiment, the specified command is invoked via a remote command execution facility, the invocation of which is embedded within, for instance, a shell script (e.g., written in PERL) or a computer program (e.g., written in C) located on the host unit.

**[0030]** One example of a remote command execution facility is the RSH facility of UNIX. RSH is described in UNIX Network Programming, by W. Richard Stevens, Prentice Hall, 1990, ISBN 0-13-949576-1, which is hereby incorporated herein by reference in its entirety.

**[0031]** The remote command execution facility transports the specified command from the host unit to the remote units to be executed on the remote units and forwards back to the host unit the "standard output" and "standard error" generated during execution of the specified command.

**[0032]** The "standard output" includes the output of the specified command, and the "standard error" includes a list of error messages issued by the command. However, neither "standard output" nor "standard error" includes the status code (e.g., an exit or return code) of



bility of the present invention is depicted in FIG. 3 and described in detail below. For this discussion, reference is also made to FIG. 2. The reference numerals within the 200's can be found in FIG. 2.

[0049] Referring to FIG. 3, initially, a subroutine (e.g., the runitrc subroutine) is invoked in order to have a specified command (designated by cmd) executed on a remote unit, STEP 300. In one example, subroutine 206 is a library routine invoked from within shell script 202 using invocation 204. In another embodiment, however, the subroutine is invoked from within a computer program, such as a program written in C.

[0050] Thereafter, a remote command execution facility (e.g., RSH) invocation is issued from within the subroutine in order to execute a runitrc command on a remote unit, which in turn will remotely execute the specified command (cmd), STEP 302. In one instance, the remote command execution facility is invoked by invocation 208, as described above.

[0051] In particular, the remote command execution facility (e.g., RSH) transports the string "runitrc cmd" to the remote unit designated by "remote".

[0052] The command, runitrc, is then run on the remote unit under the control of the remote command execution facility, STEP 304. Specifically, the statements within the runitrc command are executed inline, one at a time. At a particular point within the code for the runitrc command, an invocation is reached for the specified command to be executed on the remote unit. In one example, the specified command, designated by cmd, is invoked by invocation 212. It should be noted that cmd represents a string of one or more words that identify the specified command to be remotely executed.

[0053] The specified command is then executed, STEP 306, and the output of the specified command, if any, is captured in "standard output" and the error messages, if any, are captured in "standard error". Additionally, in accordance with the principles of the present invention, the status code of the specified command is captured, STEP 308. In one example, the status code is captured using the following assignment:

\$rc=\$?:

[0054] Where:

\$rc is the variable to contain the status code; and

\$? is a variable that contains the status code of the most recently executed command (i.e., the specified command, in this instance).

[0055] Thereafter, the status code (e.g., the value of \$rc) is written to "standard output", using print statement 214 within the runitrc command code. One embodiment of the syntax of the print statement is as follows: print(stdout ">>>The status code from the command was: \$rc");.

[0056] In particular, the status code of the specified command is captured within the variable \$rc and a spe-

cial text string ">>>The status code from the command was:" is added to the already provided "standard output" text. That is, in one example, this special text line is added to the last line of "standard output". If there is no output, then this special text line will be the only line within "standard output".

[0057] Thereafter, invocation of the runitrc command is terminated, when, for instance, exit statement 216 within the runitrc command is reached, STEP 310. After completion of the runitrc command, the status code is returned to the calling subroutine 206, the runitrc subroutine, via the remote command execution facility. In particular, the remote command execution facility forwards to the calling subroutine the "standard output", which now includes the status code of the specified command. Additionally, "standard error" is returned. The manner in which "standard output" and "standard error" are forwarded from a remote unit to a host unit is known to those skilled in the art.

[0058] "Standard output", including the status code line, is returned within the runitrc subroutine to the variable @stdout (reference numeral 208). Subsequently, other processing within the subroutine can take place. For instance, a determination is made as to whether the status code is available, STEP 314. In particular, the last line of "standard output" is stripped off and the subroutine code looks for the numeric value following the text string ">>> The status code from the command was:". If, for some reason, the status code is not returned, an error message is passed to the invoker of the subroutine (e.g., shell script 202), STEP 316.

[0059] If, however, the status code is returned, the status code is provided to the invoker of the subroutine, STEP 318. In one example, the status code is returned to the shell script using the statement, return \$rc (reference numeral 218).

[0060] The status code is returned to the shell script into the variable \$x in invocation 204. At this time, the code of the shell script can take further action. For instance, conditional logic can be included in order to perform further tasks depending on the value of the status code.

[0061] In the above example, the status code is added to the last line of "standard output". This is only one example, however. In another embodiment, the status code can be added to other places within "standard output". In yet a further embodiment, the status code can be returned with "standard error".

[0062] In one example of the present invention, the status code is returned in the "standard output", even if the coder of the remote specified command indicates that no output is to be generated.

[0063] In accordance with the principles of the present invention, the remote command execution facility is provided with the ability to return a status code of a remotely executed command from a remote unit to a host unit. This advantageously allows the calling script or program to perform certain other tasks, which depend on the

proper return of the status code. The present invention provides an easy mechanism for interactive shell scripting environments executing remote command execution facilities to receive accurate status codes from remotely executed commands. With the present invention, the operating system code (e.g., the UNIX operating system code) need not be changed.

**[0064]** In accordance with the principles of the present invention, the command can be sent from a host unit to a plurality of remote units. Each of the remote units would include the runitrc command code, in this example. A status code would then be returned from each of the remote units. In a further embodiment, multiple host units can be used to send commands to one or more remote units.

**[0065]** The present invention can be included in an article of manufacture (e.g., one or more computer program products) having, for instance, computer useable media.

**[0066]** The media has embodied therein, for instance, computer readable program code means for providing and facilitating the capabilities of the present invention. The article of manufacture can be included as a part of a computer system or sold separately.

**[0067]** The flow diagrams depicted herein are just exemplary. There may be many variations to these diagrams or the steps (or operations) described therein without departing from the spirit of the invention. For instance, the steps may be performed in a differing order, or steps may be added, deleted or modified. All of these variations are considered a part of the claimed invention.

**[0068]** The present invention also relates to a system of propagating a status code from a remote unit to a host unit, said system comprising:

means for invoking from within a subroutine on a host unit a remote command execution facility to execute a first command;

means for executing said first command on a remote unit;

means for executing a second command on said remote unit via said first command; and

means for forwarding a status code of said second command from said first command on the remote unit to said host unit.

**[0069]** The system of the previous paragraph further comprises either a) means for invoking said subroutine from within either a shell script or a computer program; or

b) means for adding said status code to standard output generated for said second command, said adding being performed during execution of said

first command;

means for exiting said first command; and

means for passing said standard output from said remote unit to said host unit using said remote command execution facility.

**[0070]** Although preferred embodiments have been depicted and described in detail herein, it will be apparent to those skilled in the relevant art that various modifications, additions, substitutions and the like can be made without departing from the invention as defined in the following claims.

## Claims

1. A system of propagating a status code from a remote unit (102) to a host unit (102a), said system comprising:

a host unit adapted to pass from the host unit to a remote unit a command (300) to be executed on said remote unit, said host unit using a remote command execution facility (302); and

said remote unit being adapted to execute said command and to forward a status code (318) of said command from said remote unit to said host unit, said remote unit using said remote command execution facility to forward said status code.

2. The system of claim 1, wherein said remote command execution facility being incapable of returning said status code from said remote unit is enabled to return said status code.

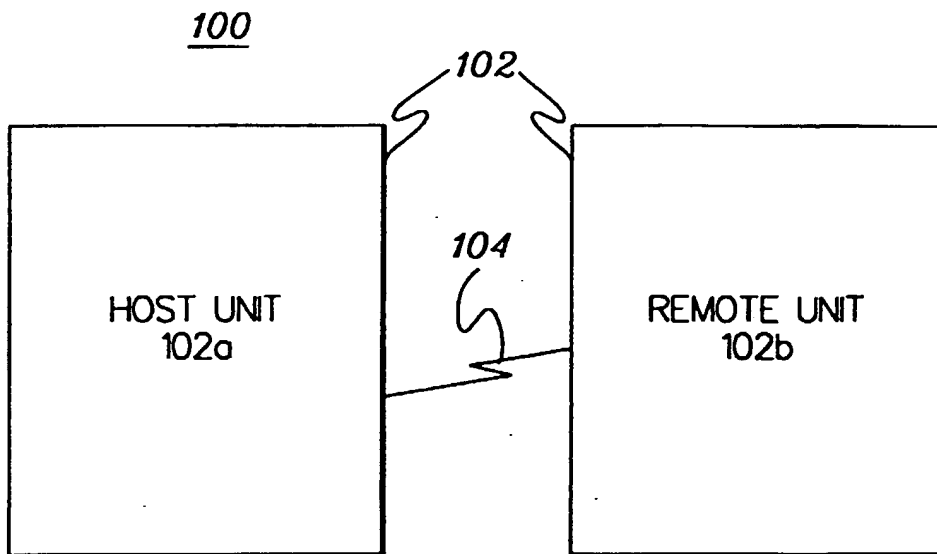
3. The system of claim 1, wherein said host unit is further adapted to issue a remote command execution facility invocation to execute said command on said remote unit, said remote command execution facility invocation identifying said command.

4. The system of claim 3, wherein said remote command execution facility invocation is issued from within a subroutine (302), said subroutine being called from within either a shell script or a computer program.

5. The system of claim 3, wherein said remote unit is further adapted to run another command (306) on said remote unit, said another command being identified on said remote command execution facility invocation, and wherein execution of said command is under control of said another command.

6. The system of claim 5, wherein said remote unit is further adapted to pass said status code of said command from said another command to said host unit using capabilities of the remote command execution facility. 5
7. The system of claim 1, wherein said remote unit is further adapted to:
- include said status code in standard output 10  
generated during execution of said command;  
and
- pass said standard output to said host unit. 15
8. The system of claim 7, further comprising means for removing said status code from said standard output. 20
- 25
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- 55





*fig. 1*

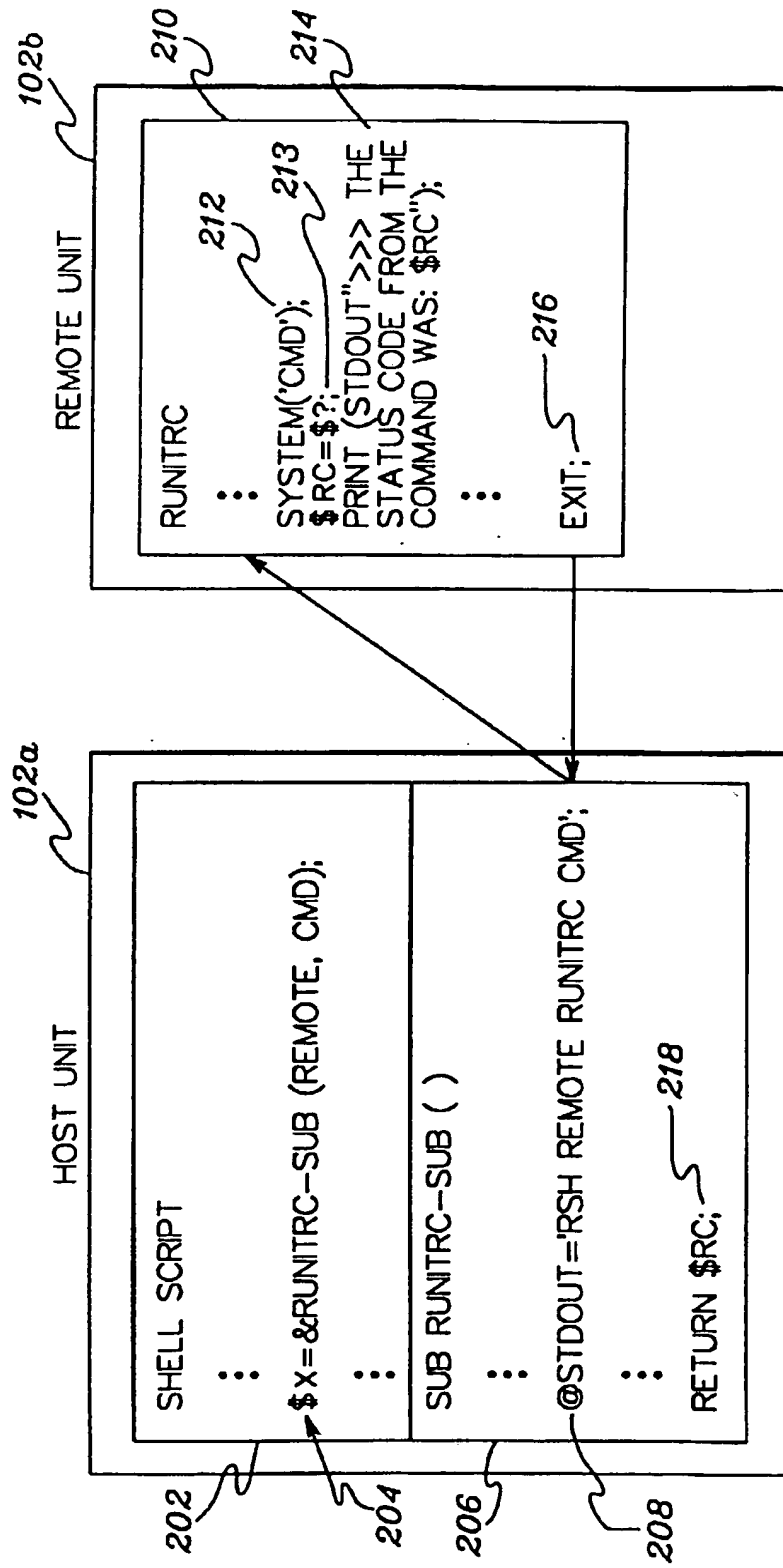
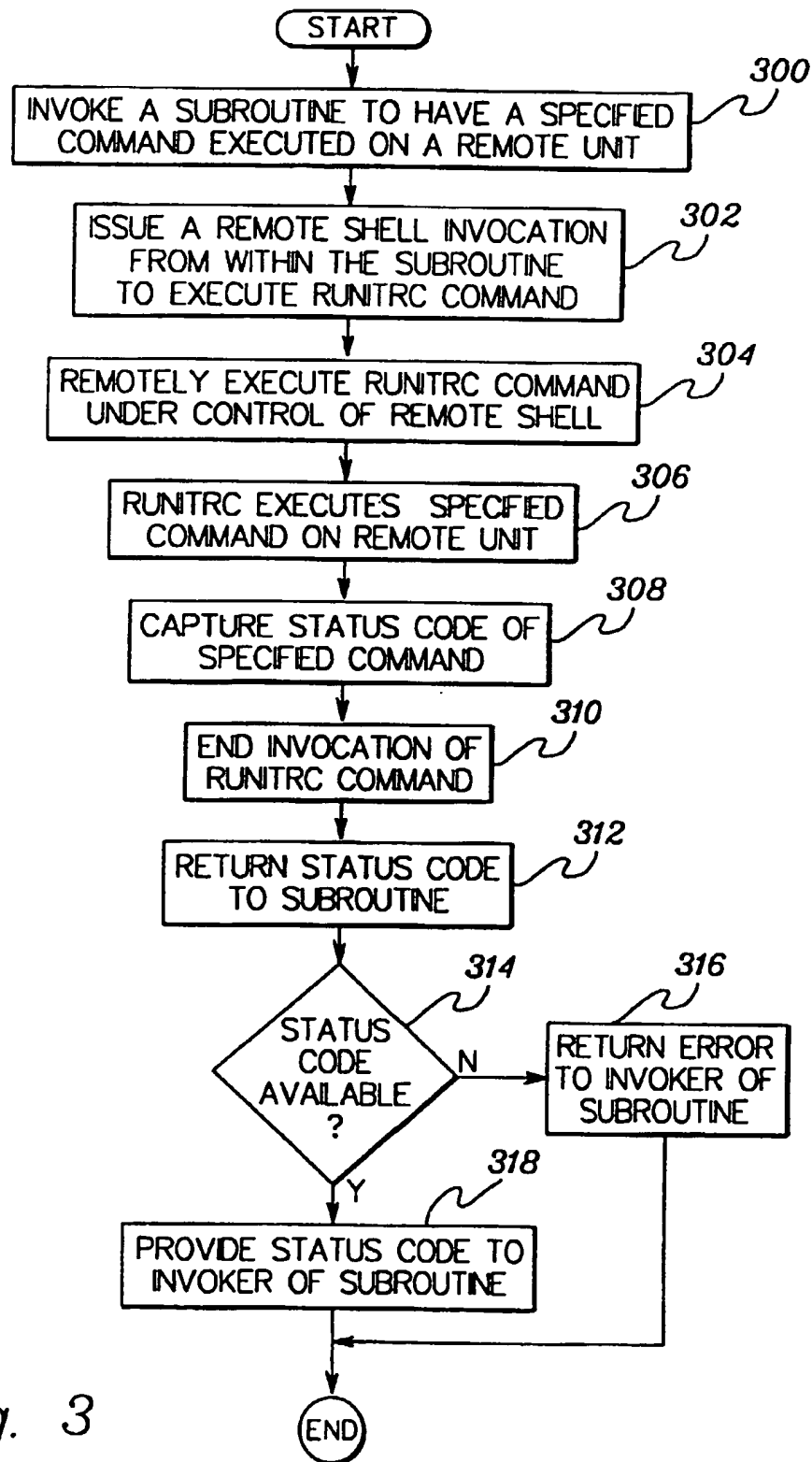


fig. 2

*fig. 3*



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(72) Inventor: **Russell, Richard Charles**  
**Red Hook, NY 12571 (US)**

(74) Representative:  
**Burrington, Alan Graham Headford**  
**Alan Burrington & Associates**  
**41 The Street**  
**Ashtead**  
**Surrey KT21 1AA (GB)**

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(71) Applicant: **INTERNATIONAL BUSINESS  
MACHINES CORPORATION**  
**Armonk, NY 10504 (US)**

(54) **System of propagating a command status code from a remote unit to a host unit**

(57) Propagation of a command status code from a remote unit to a host unit. A command to be executed on a remote unit is passed from a host unit to the remote unit, using a remote command execution facility, such as the remote shell (RSH) facility of UNIX. The command is executed on the remote unit and the status code of the command is forwarded from the remote unit to the host unit, using the remote command execution facility. In one example, the status code is appended to standard output, so that it can be retrieved and used in further processing.

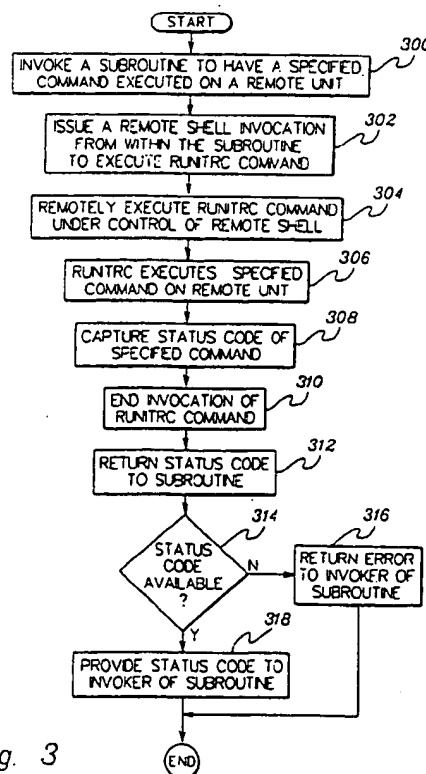


fig. 3

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## EUROPEAN SEARCH REPORT

Application Number  
EP 98 30 3263

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X A	US 5 590 288 A (NELSON JOHN W ET AL) 31 December 1996 * column 6, line 64 - column 8, line 3 * ---	1,3,4,7, 8 2,5,6	G06F9/46
X A	US 5 113 502 A (MERRILL RICHARD A ET AL) 12 May 1992 * column 2, line 1 - line 4 * * column 2, line 42 - line 53 * * column 10, line 42 - line 58 * * column 17, line 32 - line 50 * * column 18, line 42 - column 19, line 28 * ---	1,3,4,7, 8 2,5,6	
A	EP 0 414 624 A (IBM) 27 February 1991 * column 3, line 30 - line 36 * * column 6, line 47 - column 7, line 7 * * column 8, line 36 - column 9, line 56 * ---	1-8	
A	KWONG S ET AL: "DESIGN AND IMPLEMENTATION OF REMOTE PROCEDURE CALL BASED ON ISO/OSIREFERENCE MODEL" PROCEEDINGS OF THE REGION TEN CONFERENCE (TENCON), BEIJING, OCT. 19 -21, 1993, vol. 1, 19 October 1993, pages 544-548, XP000463347 YUAN BAOZONG * paragraph 3 * * paragraph 4 * -----	1	TECHNICAL FIELDS SEARCHED (Int.Cl.6) G06F
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 11 March 1999	Examiner Michel, T
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EP 98 30 3263

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11-03-1999

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